

Bare Plurals, Multiplicity, and Homogeneity*

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Abstract This paper presents a novel view on the multiplicity implication of existential bare plurals. Deviating from the conventional wisdom that scalar implicatures are involved, we argue that the facts can be conceived of in terms of the general trivalence of plural predication, which has been described for definite plurals under the name of *homogeneity*.

Keywords Bare Plurals, Multiplicity, Homogeneity, Trivalence, Implicatures

1 Introduction

There is a question in formal semantics of whether the denotation of plural nouns like *zebras* in an existential bare plural noun phrase encompasses only pluralities of zebras (*exclusive reading*) or also atomic individuals (*inclusive reading*). At its simplest, the puzzle is that while (1a) seems to imply that Mary saw multiple zebras, (1b) entails that she didn't see a single such animal. Thus, the plural noun seems to have an exclusive reading in (1a), but an inclusive reading in (1b).

- (1) a. Mary saw zebras.
b. Mary didn't see zebras.

Prior engagements with the issue have mostly resulted in analyses of the multiplicity component of the meaning of (1a) as some kind of quantity implicature (Sauerland 2003, Sauerland et al. 2005, Spector 2007, Zweig 2008, 2009, Ivlieva 2013). That is to say, the meaning of the plural noun is inclusive, and so the literal meaning of (1a) is that Mary saw one or more zebras. But there is an intuition that if she had seen only one zebra, the speaker would have used the singular, so that the multiplicity implication arises as a quantity implicature; the difference between the variants of the implicature approach lying in how they implement this intuition. In downward-entailing contexts such as under negation, this quantity implicature naturally disappears, and so there is an inclusive reading in (1b). An exception to this is the account by Farkas & de Zwart (2010), who assume that both an inclusive and an exclusive meaning are available and give an optimality-theoretic treatment of the choice between them.

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The purpose of this paper is to propose an alternative perspective which uses quite different, but independently available conceptual resources: A view of multiplicity as likened to the homogeneity property of plural predication. The core datum illustrating the latter phenomenon is the following: A predicate applied to a plurality (denoted by a definite plural) is not true of this plurality when it is true of some, but not all of its parts; but neither is its negation true in such a case. Rather, both sentences have a third truth value, often called *undefined* for convenience.¹

- (2) Mary read the books.
true iff *Mary read all the books*
false iff *Mary read none of the books*
undef. otherwise
- (3) Mary didn't read the books.
true iff *Mary read none of the books*
false iff *Mary read all of the books*
undef. otherwise

We proposed that in the same way as (2) is undefined when Mary read only half the books, (1a) is undefined when Mary saw exactly one zebra. From this assumption, substantive predictions about the behaviour of bare plurals follow immediately based on what is known independently about homogeneity. These will be discussed in sections 2 and 3. In section 4, we finally sketch how, instead of being simply stipulated, the trivalent behaviour of existential bare plurals can actually be derived from the homogeneity of plural predication. We close by mentioning a potential puzzle brought up by Magri (2011), which the homogeneity theory might have an edge in dealing with, in section 5.

2 Context-Dependence

Experimental data from Grimm 2013, 2014 indicate that whether a bare plural is interpreted inclusively or exclusively is dependent on contextual factors. Subjects were presented with questions and asked which answer, *yes* or *no*, is more appropriate in a scenario where there is only one witness. For questions about concrete physical configurations, like (4a), they preferred *no*, indicating an exclusive understanding, while for others, like (4b), they preferred *yes*.

- (4) a. Is the mug in this picture sitting next to computers?
 b. Did your team terminate projects this fiscal quarter?

It is easy to see why this would be so: Most likely, in a context in which (4b) is asked, it is not relevant how many projects were finished, just that at least one was finished. This is, in fact, the exact intuition that one of Grimm's subjects reported in a comment on the experiment. This context, where the distinction

¹ Cf. Schwarzschild 1994, Löbner 2000, Gajewski 2005, Križ 2015, *pace* Breheny (2005) and Magri (2014).

between alternatives is not relevant, is precisely the kind of situation where an implicature theorist would expect no strengthening to occur.²

The homogeneity theory has its own way of accounting for this context dependence. From definite plurals, we know the phenomenon of *non-maximality*, which consists in a plural predication being acceptable even when the predicate is, strictly speaking, false of some members of the plurality, as long as the exceptions are somehow irrelevant in the context at hand.

Križ (2015) has argued that non-maximality is linked to homogeneity and presents a theory trying to implement this: a sentence that is undefined due to homogeneity can still be used if it is true enough, where a sentence is true enough if it is not false and the actual situation is, for current purposes, equivalent to one where the sentence is literally true. If we apply this to our sentences with bare plurals, the result is exactly as desired: The sentence can be used in a single-witness situation if and only if a situation with a single witness is, for current purposes, equivalent to one with multiple witnesses, that is to say, if it doesn't matter whether there are one or multiple witnesses.

3 Complex Sentences

3.1 Negation

The most distinctive prediction of our approach concerns the interaction of bare plurals with negation. Negation switches around truth and falsity conditions, but leaves the third truth value alone. By assumption, (5a) is neither true nor false when Mary saw exactly one zebra, and so its negation (5b) is also predicted to be neither quite true nor quite false in such a situation, which strikes us as reasonable.

- (5) a. Mary saw zebras.
b. Mary didn't see zebras.

The implicature approach does not predict this equal status. For the positive sentence, a judgement of intermediacy or indeterminacy may be rooted in the fact that the literal meaning is true while the implicature is false (as found to some extent for scalar implicatures by Križ & Chemla 2015). The negative sentence, however, does not have an implicature that could differ in truth value from the literal meaning; it just has the literal meaning that Mary didn't see one or more zebras, which is plainly false when she saw exactly one. Analogous predictions exist for all downward-entailing environments, where implicature-based approaches predict an inclusive reading and no implicature, hence no potential for a third status besides truth and falsity.

² We assume that the implicature theorist has some answer to how to treat the case of question answering in particular, that is to say, a view on whether the implicature is, contrary to common wisdom, computed locally within the question or whether it is computed on the answer.

3.2 The Scope of Quantifiers

Beyond negation, it is natural to look at what happens when a bare plural occurs in the scope of a quantifier. Our assumption is that the predicate *saw zebras* is trivalent: It is true of individuals that saw multiple zebras, false of those who saw none, and undefined of individuals who saw no zebras at all. The question is, then, how quantifiers (over atoms) apply to such a trivalent predicate. This is exactly the question that was investigated experimentally by Križ & Chemla (2015) for homogeneity with definite plurals. The pattern that they found, based on data for the quantifiers *every*, *no*, and *exactly two*, is captured by the following rule:

- (6)
1. Let P^1 be that predicate which is just like P except that it is true of all the individuals where P is undefined, and P^0 that predicate which is just like P except that it is false of all the individuals where P is undefined.
 2. For any quantifier Q , if $Q(P^1)$ and $Q(P^0)$ have the same truth value, then $Q(P)$ also has that truth value.
 3. Otherwise, $Q(P)$ is undefined.

For the case of definite plurals, this can be turned into an intuitively usable rule as follows: Replace the definite plural either with an existential or with a universal. If both of the resulting sentences are true, the original sentence is true, if both are false, the original sentence is false. Otherwise it is undefined. If we do this replacement for (7), for example, we obtain (7a) and (7b).

- (7) Every student read the books.
- a. Every student read some of the books.
 - b. Every student read all of the books.

The overall truth and falsity conditions are then as in (8):

- (8) Every student read the books.
- true** *iff every student read all of the books [(7a) and (7b) are both true]*
false *iff at least one student read none of the books [(7a) and (7b) are both false]*
undef. *otherwise [(7a) is true and (7b) is false]*

The bare plurals, the analogous procedure is to replace the bare plural *zebras* once with *a zebra* and once with *multiple zebras*.³ When we apply this to a sentence with a universal quantifier, we get the following reasonable result.

- (9) Every student saw zebras.
- true** *iff every student saw multiple zebras*
false *iff at least one student didn't see any zebra*
undef. *otherwise*

³ In order to be applicable when a collective predicate is involved, the two variants have to be formulated as *one or more* and *two or more*, respectively.

These truth conditions are predicted by all existing theories, but Spector (2007) points out that under certain assumptions, his approach generates an additional reading, shown in (11).

(10) Every student saw zebras.

true *iff every student saw a zebra and at least one saw multiple zebras*

Such a reading, while difficult to isolate, seems to be at least marginally available. Note, however, that in order to derive it, Spector's theory requires that in generating the alternatives during implicature computation, one can replace more than one scalar item at the same time; in this case, *every* and the bare plural *zebras*. In particular, (11b) is required as an admissible alternative to (11a) (for details, the reader is asked to consult the original paper). This is not entirely unproblematic, as the availability of such multiple replacements has been questioned by Fox (2007) and Magri (2009).

(11) a. Every student saw zebras.

b. Some student saw a zebra.

Interestingly, the homogeneity theory has a different way of conceptualising this reading. In terms of literal semantics, the sentence is undefined in the situation in question. However, if the purposes of the conversation are such that it is irrelevant whether only one or all of the students saw multiple zebras as long as at least one did, then the sentence would still be true enough in such a case. Of course, depending on what the speakers take to be relevant, the sentence could also be true enough in a situation where, in fact, each student only saw one zebra. This is not excluded by any other theory, either, since it simply corresponds to the reading without an implicature.

Non-monotonic quantifiers such as *exactly one* are a tricky case where many existing theories stumble. The predictions of the homogeneity theory are as in (12), the crucial aspect being that in order for the sentence to be true, no more than one girl is allowed to have seen *any* zebra, while the one who did see one must still have seen more than one.

(12) Exactly one girl saw zebras.

true *iff one saw multiple zebras and all other girls saw none*

false *iff either (i) more than one girl saw at least one zebra and the number of girls who saw multiple zebras is not one, or (ii) no girl saw any zebra*

undef. *otherwise*

This is predicted by Spector's (2007) theory as well, but not by any other that we are aware of. For all of the other implementations of the implicature approach, the exhaustification that effectively makes the meaning of the plural noun exclusive is done locally within the verb phrase, and it either occurs or does not occur depending on whether it results in a strengthening of the overall sentence. But whichever is chosen, the resulting reading is either (13a) or (13b), both of which are weaker than (12).

- (13) a. Exactly one girl saw a zebra.
 b. Exactly one girl saw more than one zebra.

Since Farkas & de Zwart's (2010) theory is phrased in terms of the optimal choice of denotation for the plural noun, it has the same problem (as the authors duly acknowledge in their fn. 25): Depending on various factors, the optimal denotation will be either inclusive or exclusive ((13a) or (13b), respectively), but it will be *one* of the two. Whichever is chosen, the result, when embedded under *exactly*, does not yield the truth conditions in (12).

4 From Homogeneity to Bare Plurals

So far, we have discussed predictions based on the stipulation that an existential bare plural yields undefinedness when there is exactly one (atomic) witness, and that this undefinedness is the same that arises with plural predication due to homogeneity. Naturally, it would be desirable to actually derive this parallel from deeper principles. In this section, we will sketch such a derivation, although the presentation of a full formal system would go beyond the scope of this paper.

We can think of homogeneity as a property of lexical predicates, which are trivalent in a certain way. The formulation given by Križ (2015), which applies to both distributive and collective predicates, is as follows:

(14) **Generalised Homogeneity**

A homogeneous predicate P is undefined of a plurality a if it is not true but there is a plurality b that overlaps with a (i. e. has constituent individuals in common) such that P is true of b . (Križ 2015)

In general, this entails that if a homogeneous predicate is true of some plurality of objects, it cannot be false of any subplurality. The plural noun *zebras* is plausibly a lexical predicate to which this constraint applies. Given that it ought unquestionably to be true of pluralities of multiple zebras, it has to be either true or undefined of atomic zebras. The former option corresponds to the inclusive, bivalent meaning; the latter is what we need to assume for our theory.

The bare plural noun phrase itself introduces an existential quantifier over pluralities. More concretely, we assume that *Mary saw zebras* has the logical form in (15) with a silent existential determiner \mathcal{E} , restricted neither to atoms nor to pluralities, which is applied to the plural noun. By assumption, this existential determiner is true of two predicates if and only if there is an individual of which both predicates are true.

- (15) $\mathcal{E}(\text{zebras})(\lambda x. \text{Mary saw } x)$

Both arguments of the determiner are trivalent predicates: the restrictor is undefined of atomic zebras, and the scope is undefined of pluralities of which Mary only saw a part. Hence we need to figure out how to combine them.

In section 3.2, we had rule (6) for application of a quantifier to a trivalent argument. It is easy to generalise this rule to multiple arguments,⁴ but there is another, more important obstacle: It is appropriate only for quantifiers that quantify over atoms. If we apply it to a quantifier over pluralities, we obtain bizarre results. Take the sentence (16a), which we will assume to have the logical form in (16b). This sentence ought to be false in a situation where Mary saw only one zebra.

- (16) a. Mary saw two zebras.
 b. $\mathcal{E}(\text{two zebras})(\lambda x. \text{Mary saw } x)$

The predicate *two zebras* is not lexical, so it is not restricted by homogeneity: It is true of dualities of zebras and simply false of everything else, and we have nothing more to do when applying the determiner to it.⁵ The quantifier $\mathcal{E}(\text{two zebras})$ is consequently true of all predicates which are true of a duality of zebras.

The scope predicate $\lambda x. \text{Mary saw } x$ is true of all pluralities which are such that Mary saw all of their members, false of all pluralities such that Mary saw none of their members, and undefined of those where Mary saw only some members. In particular, it is undefined of all duality of zebras which contain the one zebra that Mary saw. Now depending on how we resolve these undefined cases, the quantifier $\mathcal{E}(\text{two zebras})$ is either true or false of the result, and so (16) should be undefined.⁶ What we want, intuitively, to avoid this is that the application rule treats the predicates as if it were false of those dualities which contain a zebra that Mary didn't see, even if it is actually undefined because the second part of the duality is the zebra that Mary did see. The application rule is easily modified to incorporate this:

- (17) 1. Let P^* be that predicate which is just like P except that it is false of all x such that P is undefined of x if there is an individual y which overlaps with x and of which P is false.
 2. Apply rule (6) to Q and P^* . The result is the truth value of Q for P .

The essential intuition that we look at the different ways in which a case of undefinedness can be resolved is retained here, but it is restricted in a particular way: In a manner of speaking, a case that is tainted by falsity can never be resolved to truth, where "tainted by falsity" means that the individual in question overlaps with an individual of which the predicate is false.

Note that all of this is needed independently from bare plurals: Since quantifiers like *two zebras* can be applied to collective predicates, as in (18), they need to be able to quantify over pluralities.⁷ Naturally, we do not want to make them

⁴ Namely, the determiner is true/false of a sequence of arguments $\langle P, Q \rangle$ if it is true/false for all sequences $\langle P^i, Q^j \rangle$ with $i, j \in \{0, 1\}$, and otherwise undefined.

⁵ In consequence, it is not decisive that we have chosen to treat *two zebras* as a predicate with a silent existential determiner applied to it; we could also have taken *two* to be a determiner by itself.

⁶ It would be false only in degenerate models where there is only one zebra so that there are no dualities of zebras at all.

⁷ And they should do that in such a way that the second version of (18) is false, rather than undefined, if the piano was carried upstairs by one zebra alone.

ambiguous between a version that quantifies over atoms and one that quantifies over pluralities, so we generalise to the latter case.

(18) Two zebras met / carried a piano upstairs.

When we apply this apparatus to bare plurals, we find that the fact that the restrictor is undefined of atoms is what gives rise to exactly the trivalent behaviour that we want. The bare plural *zebras* is undefined of atomic zebras. Those do not overlap with any pluralities of which *zebras* is false, so the change in the application algorithm actually has no effect here, and the undefinedness can be resolved in either direction. This is why we can intuitively apply the rule of substituting the bare plural with *one or more* (equivalent to forming P^1 by resolving the undefined atomic cases to truth) and *multiple* (equivalent to forming P^0).

The meaning of the bare plural noun is the only ingredient that is specific to the construction under discussion; everything else follows from the independently known behaviour of homogeneity. And the meaning of the bare plural itself is also informed by the theory of homogeneity, in that it is essentially the exclusive meaning, but modified so as to obey the homogeneity constraint on lexical predicates. The result is, in a sense, intermediate between the inclusive and the exclusive reading, in that it assigns the third truth value to atomic individuals.

5 Mass Nouns

Magri (2011) points out that if there is such a thing as a plurality inference for mass nouns, then the implicature approach is in trouble, since it relies on the contrast between a singular and a plural indefinite, which doesn't exist in the case of mass nouns. Magri suggests that such plurality inferences do seem to exist with *furniture*-type mass nouns. (19a), for example, would normally be understood to imply that John bought more than one piece of furniture, while (19b) clearly means that he didn't buy even a single piece of furniture.

- (19) a. John bought furniture yesterday.
 b. John didn't buy furniture yesterday.

In order for the implicature theory to capture this fact, it would have to be assumed that *furniture* has an alternative *a piece of furniture* (which in turn has alternatives of the form *n pieces of furniture*), which, in light of the fact that the latter appears quite a bit more complex, is dubious (Katzir 2007).

On the homogeneity theory, we could assume that the nominal predicate *furniture* is undefined of single pieces of furniture. There is no obvious reason why this should be so, but there is also no obvious reason why it should not, and given the general deep parallels between plurals and mass nouns, it is not altogether too implausible.

6 Conclusion

The best existing theories of the plurality inference associated with existential bare plurals differ only subtly in empirical coverage. The current theory maintains the core good empirical results of its predecessors, but it diverges from them in interesting ways. It is minimally distinguishable from Spector's (2007) by the prediction that negated sentences with bare plurals have an intermediate status between truth and falsity under certain conditions (whereas Spector predicts falsity in those cases), and from all other theories by its predictions for the behaviour of bare plurals in the scope of non-monotonic quantifiers such as *exactly one*. The relevant judgements are arguably subtle and may not allow us to robustly adjudicate between the theories at present.

Importantly, the proposed theory employs very different conceptual resources from previous approaches to the phenomenon, effectively reducing it entirely to the trivalence phenomenon known as homogeneity that is associated with plural predication. This provides an alternative over other approaches in case their assumptions (multiple exhaustification with non-transitive alternativehood in the case of Spector 2007; local exhaustification at the predicate level for the other implicature-based theories; optimality-theoretic disambiguation guided by various constraints in Farkas & de Zwart 2010; availability of a plausible alternative for mass nouns) are found to be unpalatable.

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